



A dendrochronological study on *Acer velutinum* in northern Iran

Majid Kiaei^{1*} and Reza Bakhshi¹

¹Department of Wood and Paper Science and Technology, Chalous Branch, Islamic Azad University (IAU), Chalous, Mazandaran, Iran

mjd_kia59@yahoo.com*

Abstract

This study was carried out to investigate the relationship between climate condition (temperature and precipitation) and tree-ring widths of *Acer velutinum* in north of Iran. A total of 13 cores from 4 trees in same site were selected to measure tree-ring. To determine the response to the climate, correlation coefficients between tree-ring widths and climate data were calculated using biological years from October of the previous year to September of the current year (by Pearson's correlation and forward stepwise). Pearson's results showed that the temperature (mean, maximum and minimum) hadn't significant effect on tree ring widths, while there is a positive relationship between monthly precipitation of August and tree-ring widths. Forward stepwise results indicated that the tree-ring width values were related to precipitation of August (57.2%) and minimum monthly temperature of March (10.8%).

Keywords: *Acer velutinum*, Dendrochronology, Tree ring, Temperature, Precipitation, Iran.

Introduction

The discipline of Dendrochronology, that is development and use of time-series by means of annual growth ring of trees, comprises a set of techniques by which the annual growth layers of trees may be assigned to a definite calendar year (Touchn & Hughes, 1999). The history of changes in the trees environment may be reconstructed using various properties of tree rings. Tree-ring properties include width, cell size, wood density, trace element composition, and radioactive and stable isotope ratios. External environmental variables affect the physiological processes that control tree growth. The annual radial growth increment produces a permanent record of these effects. Since climate is the primary limiting factor to growth in the arid and semi-arid Near East countries, the sequence of narrow and wide rings in the tree-ring chronologies is a proxy record of year to year fluctuations in climate (Touchan & Hughes, 1999). The main points in Dendro- works are:

- Site selection and sampling: Dendrochronologists must apply the law of limiting factors and the concept of ecological amplitude when they obtain their research materials in order to assure selection of trees which will give them the information they desire. This selection is referred to as "site selection" (Fritts, 1976). In sampling at least 20 trees were used per site to build site chronology.
- Crossdating: Its application provides a type of experimental control because it assures the proper placement in time of each growth layer (Fritts, 1976). Trees in dry lands can produce partially missing rings or completely missing rings. Crossdating must be used to eliminate the problems from missing or multiple rings.
- Using of Cofecha: Cofecha is a very powerful computer program to find the problems on tree-ring series. The problems can be double rings, missing rings, extreme wide or narrow rings etc. In all studies

on building chronology and further analysis, Cofecha should be used.

- Standardization: Ring widths can vary not only with fluctuations in environmental conditions, but also with systematic changes in tree age, height within the stem, and conditions and productivity of the site (Fritts, 1976). In dendrochronological studies, these systematic changes should be eliminated to make clear the influence of climate on tree-ring widths. Also because of using trees in different ages, standardization is crucially important. The other main point in standardization is to use proper standardization method. For example, a residual version can be used to make clear yearly changes and a standard version for to see also long-term variations on tree-ring chronologies.
- Response function or alternative models: After building site chronologies the main point is to find the relationships between tree-ring width and climate. The most powerful way is to compute response function (Fritts, 1976). However, mostly simple correlation coefficients or multiple regression are enough. In these analysis tree-ring series is dependent variable and mean monthly temperatures and total monthly precipitation from October, prior to growing year, to September of the current year are independent variables.
- Reconstruction: The basic purpose of dendroclimatology is to reconstruct climatic parameters, such as precipitation and temperature. In the Near East, all reconstructions are related with precipitation and drought. Reconstruction is performed in three stages, calibration, verification and reconstruction.

In this direction, Sevgi and Akkemik (2007) reported that in lower altitudes, spring and summer precipitations affect the growth of pine tree rings, but they are not statistically limiting factors. In higher altitudes, this effect is weaker.

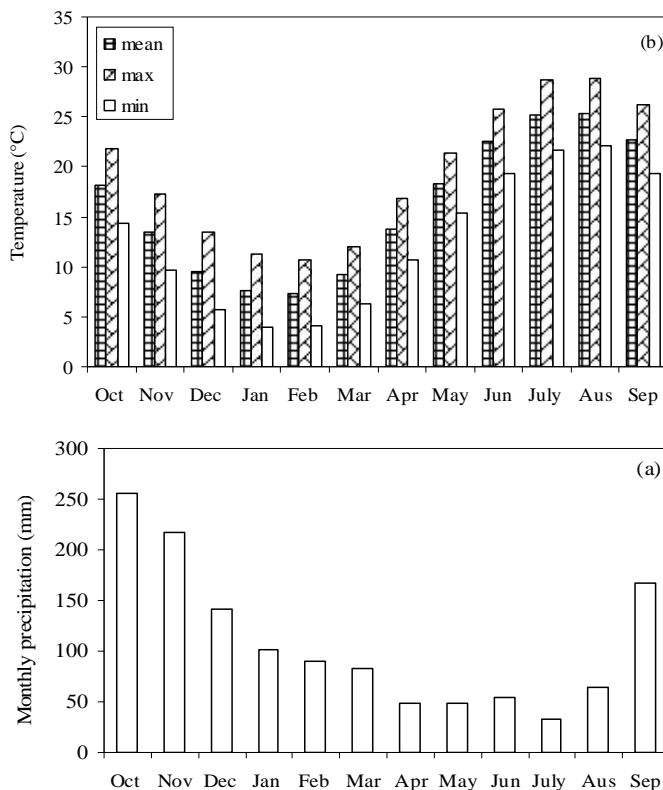
The calibration diagram between the juniper chronology and climate data from Gorgan-Iran site indicate that warm temperatures during summer of the previous year and summer of the current year are negative for tree growth. Winter rainfall between November of the year prior to growth until February shows a significant positive correlation with tree growth (Pourtahmasi *et al.*, 2007).

There isn't any study about relationship between climate condition and tree-ring of *Acer velutinum* in Iran. The aim of the present study is: 1- to construct a local tree-ring chronology, 2- to determine the relationship between climate (temperature and precipitation) and tree-ring widths in *Acer velutinum*.

Methods and materials

Study area

Fig. 1. Variations of monthly temperature and precipitation from 1978-2010



A total of 4 maple trees (*Acer velutinum* Boiss) were sampled in Khanican forests (Now-shahr province in north of Iran). All the trees were randomly selected, taking into account stem straightness and the absence of obvious decay. The age and diameter of all trees were 52-68 years and 45 to 57 cm, respectively. The study area is located at 51° 27' 45"-51° 23' 45" E longitude and 36° 37' 45"-36° 33' 15" N latitude. The altitude of sea level for this site was 100 m. The soil texture of this region was clay to clay-loam with a clay percentage of 30 to 35%. The annual rainfall and annual average temperature (1978-2010) was 1302 mm, and 16 °C, respectively.

October (256 mm) and November (216 mm) are high-rain months and July (32.6 mm) is a low-rain month. The mean monthly temperature reaches its maximum level in August (25.4 °C) and July (25.2 °C). The mean of monthly maximum temperature and monthly minimum temperature was 19.5 and 12.7 °C for Now-shahr site. The monthly mean temperature, monthly minimum temperature, monthly maximum temperature, and monthly total precipitation are shown in Fig.1.

Chronology development

A total of 13 cores from 4 trees in the one site were extracted using a Swedish Increment Borer and the samples cores were coded. The transverse surfaces of all cores smoothed and an Eclude Measuring Machine was used for measuring the tree-ring widths. An individual chronology for each tree was constructed and then correlations between all trees were calculated. The mean sensitivity and first order autocorrelation were calculated as well (Fritts, 1976), DPL and ARSTAN programs (Grissino-Mayer, 1996) were used for the chronology development. A regression model was selected as detrending method in the program ARSTAN, and the residual chronology was used for further tree-ring-climate analysis.

Tree-ring-climate relationships

Pearson's correlation and forward stepwise analyses were used to explore the climate condition (mean monthly temperature, monthly maximum temperature, monthly minimum temperature and total monthly precipitation) and ring width relationships. In this calculation, biological year, which is from October of the previous year to September of the current year (Fritts, 1976), was used. The climatic data from 1978 to 2010 were obtained the Iranian Meteorology Station near the sampled site. Surface analyses were used to determine relationship between tree-ring width and important variables interaction.

Results and discussion

Fig. 2. Tree-ring variations of maple wood from the pith to the bark

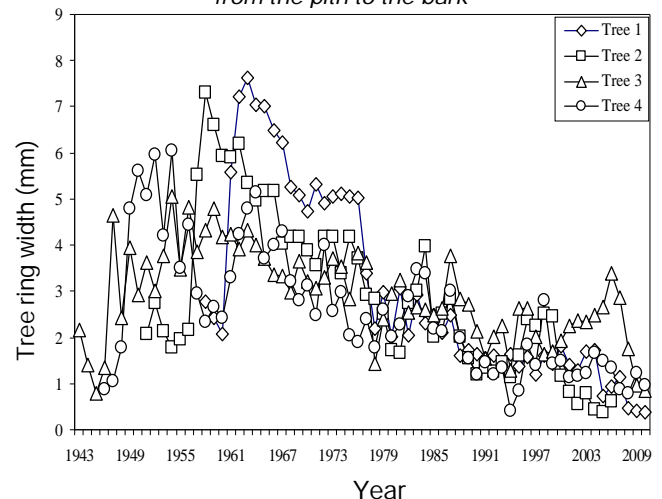
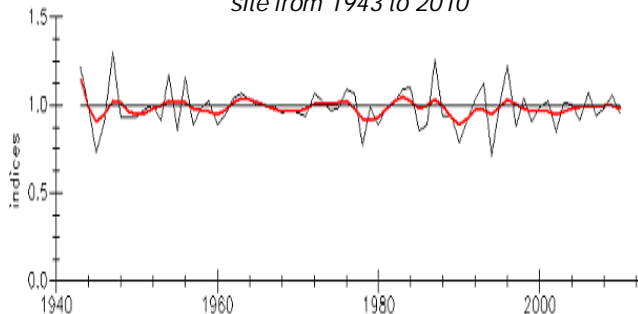




Fig. 3. Chronologies of maple tree-ring for Noshahr site from 1943 to 2010



Chronology development

A local tree-ring chronology for studied site was constructed covering the years 1943-2010 (Fig.2 & 3), the statistical characteristics of its standard, residual and ARSTAN versions are given in Table 1. Ring width variations along radial direction from the pith to the bark were decreased, as also reported by Panshin and de Zeeuw (1980). The local chronology including 68 years has little importance for dating purpose. As given in Table 1, the average correlations within trees (0.182) and radii with master (0.433), and the signal-to-noise ratio (0.495) were determined. In addition, the mean of sensitivity and first-order autocorrelation are 0.129 and -0.122, respectively. However, it can be useful in climatic and ecological as well as forestry studies.

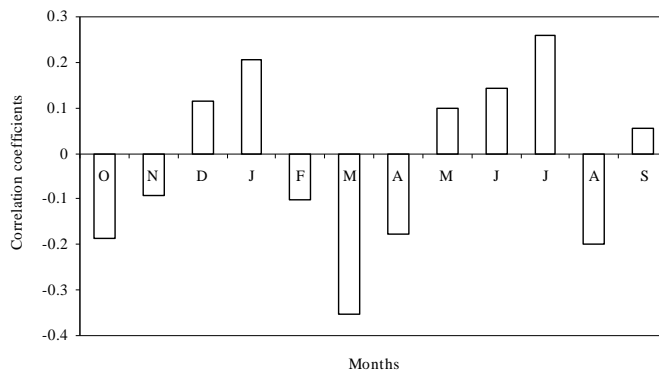
Tree-ring-climate relationships

Tree-ring-maximum monthly temperature relationships: The relationship between maximum monthly temperature and tree-ring is shown in Fig.4. Results of Pearson correlation

Table 1. ARSTAN statistics of the local mean chronology based on tree specimens in the Noshahr site. The statistics of the residual chronology are more significant than those of the standard chronology.

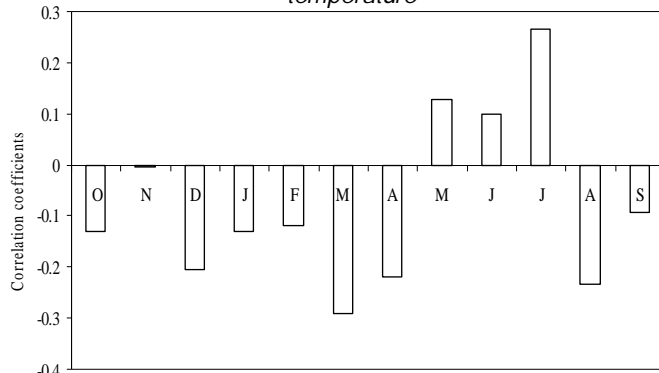
Chronology type	Standard	Residual	ARSTAN
Mean	0.9873	0.9938	0.9991
Median	0.9867	1.0039	1.0012
Mean sensitivity	0.1324	0.1297	0.1738
Standard deviation	0.1124	0.1412	0.1581
Skewness	0.3671	-2.9003	-2.1087
Kurtosis	1.3090	14.3331	12.4110
Autocorrelation order 1	-0.2357	-0.1222	-0.4007
Order 2	-0.3529	0.1170	-0.2443
Order 3	-0.2164	-0.1492	-0.0723
Variance due to auto regression	15.7%	-	13.9%
Ratio of error variance of chronologies (ARSTAN/STNDRD)			0.8461
Common interval time span 1963 to 2003 41 years 4 trees			
Mean correlations	Detrended series	Residues	
Between trees	0.182	0.171	
Radii vs mean	0.433	0.435	
Signal-to-noise ratio	0.495	0.498	
Agreement with population chron	0.331	0.332	
Variance in first eigenvestor (%)	23.98	21.41	
Chron common interval mean	0.985	1.001	
Chron common interval std dev.	0.108	0.093	

Fig. 4. Relationship between tree-ring and maximum monthly temperature



showed that maximum monthly temperature hadn't significant effect on tree-ring of *Acer velutinum*. The relationships between ring width and maximum monthly temperature in January, May, June, July, September of the current year and December of the previous year are positive. Highest and lowest of correlation between maximum monthly temperature and tree-ring were found in March ($r = -0.352$) and September ($r = 0.055$) months, respectively.

Fig. 5. Relationship between tree-ring and minimum monthly temperature



Tree-ring-minimum monthly temperature relationships: The relationship between minimum monthly temperature and tree-ring is shown in Fig.5. Results of Pearson correlation showed that minimum monthly temperature hadn't significant effect on tree-ring of *A. velutinum*. The relationships between ring width and maximum monthly temperature in May to July of the current year are positive, while there are negatively relationships between minimum temperature and other months. Highest and lowest of correlation between minimum monthly temperature and tree-ring were found in March ($r = -0.290$) and September ($r = -0.092$) months, respectively.

Tree-ring-mean monthly temperature relationships: The relationship between mean monthly temperature and tree-ring is shown in Fig.6. Results of Pearson correlation showed that mean monthly temperature hadn't significant effect on tree-ring of *A. velutinum*. The relationships between ring width and mean monthly temperature in January and May to July of the current year are positive. Highest and lowest of correlation between mean monthly temperature and tree-ring were found in March ($r = -0.348$) and September ($r = -0.019$) months, respectively.

Tree-ring-precipitation relationships: The relationship between monthly precipitation and tree-ring is shown in

Fig. 6. Relationship between tree-ring and mean monthly temperature

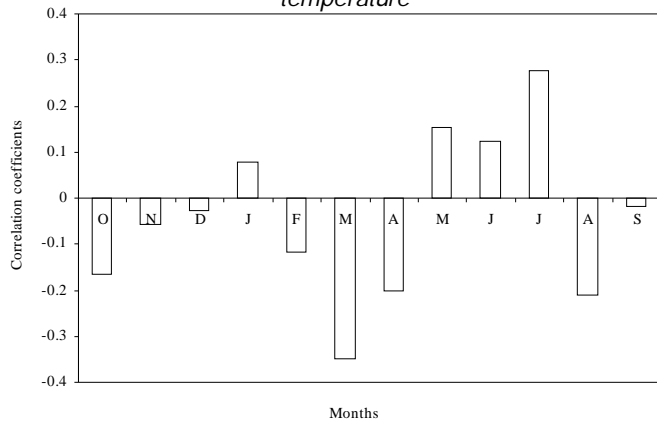


Fig. 7. Relationship between tree-ring and precipitation

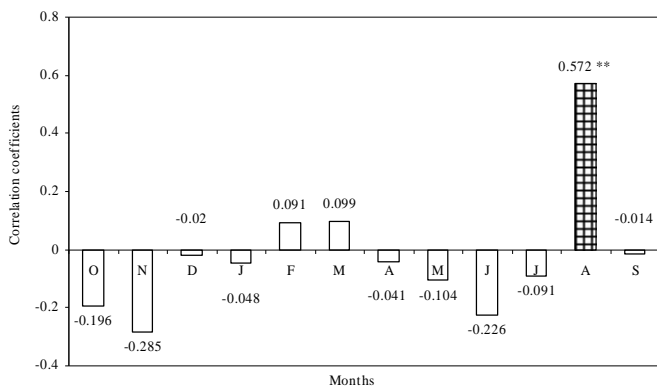


Fig.7. Results of Pearson matrix correlation showed that there are positive relationships between tree-ring and monthly precipitation in February, March and August. Only the monthly precipitation in August ($r = 0.572$) had significant difference on tree-ring of *A. velutinum*. Effects of other months on ring width are negative and not significant. Rainfall has an important on the tree-ring, as also reported by Carlquist (1988) and Leal *et al.* (2004). They reported that the lack of water in the soil texture and rainfall reduced growth of tree ring.

Relationship between climatic condition and tree ring by forward stepwise

The relationship between tree-ring widths and climatic condition were analysis by forward stepwise (Table 2). Result showed that the tree-ring width values were related to precipitation of August (57.2%) and minimum monthly temperature of March (10.8%). The highest of tree ring width values were obtained at precipitation of August higher than 250 mm and minimum temperature of March value more than 8°C. The multiple correlations between ring width-

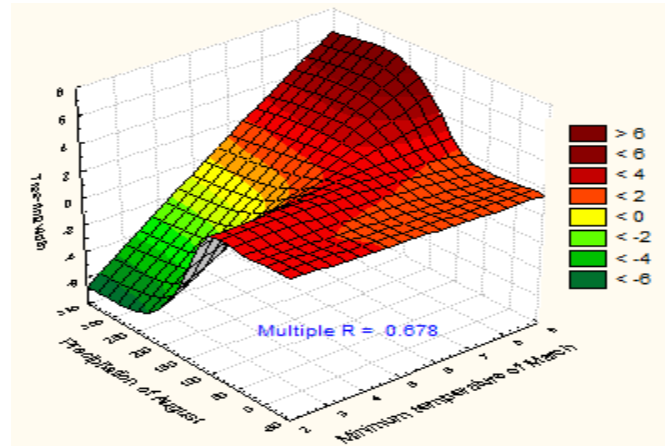
Table 2. Multiple correlations for the relationship between maple ring width and climatic condition

Properties	Correlation parameters	
	1 st	2 nd
Tree-ring width ($r = 0.678$, $r^2 = 0.459$) ^a	Precipitation of August ($r = 0.572$) ^b	Minimum temperature of March ($r = 0.108$) ^b

** Statistically significant at 99% confidence; a Multiple correlation coefficient; b Contribution of the parameter to the coefficient of determination

precipitation of August and minimum temperature of March interaction were determined 0.678 (Fig.8).

Fig. 8. Response surface between tree-ring and climate condition of maple wood in the north of Iran



Conclusion

The effects of temperature and precipitation on maple tree-ring widths were determined in north of Iran. The variations of ring width were decreased along radial direction from the pith to the bark of maple wood. Pearson's correlation results indicated that the temperature (mean, maximum and minimum) hadn't significant effect on the maple tree-ring. In addition, there are positive relationship between August monthly precipitation and tree-ring width in the maple species. Forward stepwise showed that the precipitation of August and minimum temperature of March are important factors in tree ring width variation of Maplewood.

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